Resilience-Based Optimization of Space Systems, Phase I

Completed Technology Project (2018 - 2019)

Project Introduction

With future missions of increasing complexity, duration, distance, and uncertainty, there has been a growing need for methods and tools that can permit the effective formation of early stage conceptual designs that are not only cost-effective, but also productive and resilient to failures. Current approaches are mostly tailored to evaluating independent systems but do not necessarily scale well to problems requiring a system-of-systems approach. Furthermore, current approaches are not well suited to evaluating metrics such as system resiliency. Due to extended mission duration and distance, a new paradigm is entering the space mission design area which involves systems that change over time (either by changing the system capabilities, repairing the system, or resupplying the system). This adds complexity to the mission, and uncertainty regarding the system performance.

This proposal addresses these issues with the following innovations:

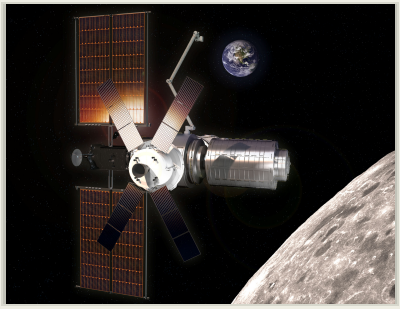
1. Development of a method and a set of tools that evaluate and optimize of system resilience during its conceptual design stage
2. Introduction of metrics that evaluate system performance as a function of other metrics such as the system cost, resilience, reliability and safety
3. Development of a scenario-based optimization to propagate uncertainty associated with the planned operation of the system

The significance of the innovations is that the proposed methods and tools will:

1. Permit the simultaneous optimization of a system-level design, a system-of-system-level design, and the resilience of a system-of-systems
2. Permit the evaluation of the impact of component-level reliabilities and subsystem designs on system-level resilience and performance
3. Allow for the propagation of uncertainty related to the planned operation of the system to be integrated into the resilience-based design optimization and evaluated concurrently with design and reliability uncertainties

Anticipated Benefits

NASA applications that can benefit from the increased resilience provided by the methods and tools developed include next-generation habitat systems, such as those being developed under NASA's NextSTEP-2 BAA, and the Lunar Orbital Platform-Gateway (including the Power Propulsion Element). Also, assets required for NASA's recently announced return to the Moon, which are complex systems within a system-of-systems, can benefit from the tools, for both robotic and human exploration of the surface.



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Organizational Responsibility

Responsible Mission Directorate:

Space Technology Mission Directorate (STMD)

Responsible Program:

Small Business Innovation Research/Small Business Tech Transfer

Small Business Innovation Research/Small Business Tech Transfer

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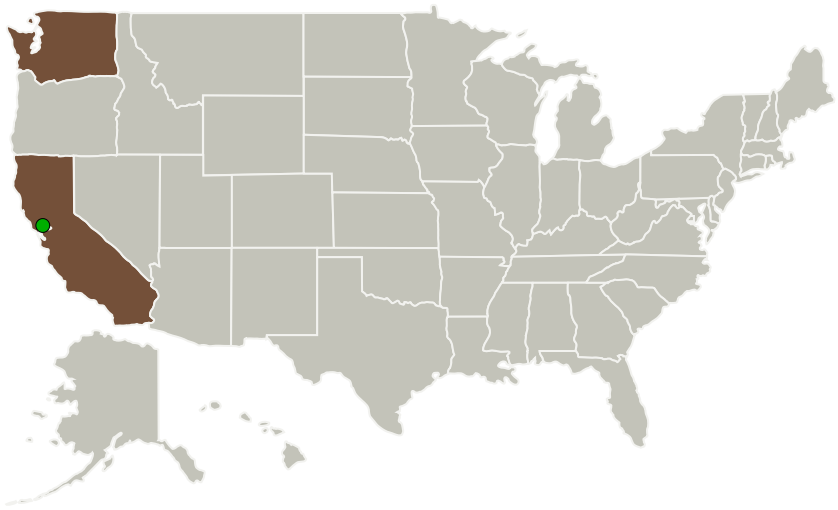
The advent of the in-space satellite assembly and manufacturing technology, coupled with the emerging ability to service satellites, means that commercial satellite architectures are undergoing a transformation. The commercial satellite industry requires tools like those developed here to optimize the level of modularity and resilience in the design of next-generation commercial satellite systems to minimize overall lifecycle cost for the commercial satellite owner.

Primary U.S. Work Locations and Key Partners



Organizations Performing Work	Role	Type	Location
Ames Research Center(ARC)	Supporting Organization	NASA Center	Moffett Field, California

Primary U.S. Work Locations	
California	Washington

Project Transitions

July 2018: Project Start

Project Management

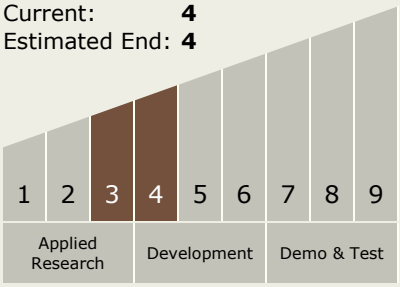
Program Director:
Jason L Kessler

Program Manager:
Carlos Torrez

Principal Investigator:
Michael J Magnin

Technology Maturity (TRL)

Start: **3**
Current: **4**
Estimated End: **4**



Technology Areas

Primary:

- TX10 Autonomous Systems
  - TX10.2 Reasoning and Acting
    - TX10.2.5 Fault Diagnosis and Prognosis

Target Destinations

Earth, The Moon

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February 2019: Closed out

Closeout Documentation:

- Final Summary Chart*(https://techport.nasa.gov/file/141269)*

Images

Briefing Chart Image
Resilience-Based Optimization of Space Systems, Phase I
(https://techport.nasa.gov/image/128428)

Final Summary Chart Image
Resilience-Based Optimization of Space Systems, Phase I
(https://techport.nasa.gov/image/126027)